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POTATO VARIETIES DERIVED FROM SPECIES HYBRIDS[1]

G. H. Rieman, D. C. Cooper and R. W. Hougas[2]

Species Hybridization and the Origin of the Potato

Potato breeding is an art, a science and a combination of agricultural practices. The application of scientific principles to the art of potato breeding, although important and developing rapidly at the present time, has not kept pace with the use of scientific breeding methods commonly employed in the improvement of many other major crops. Considerable progress has, however, been made. A comparison of modern cultivated varieties with their original wild forms, still to be found in abundance and remarkable diversity in their native habitats of the North, Central and South Americas, shows how great is the progress which has resulted from man's efforts to improve the potato plant for human needs. There is ample evidence to indicate that our present day potato varieties, for the most part, have not been derived directly from the wild species of tuber-bearing *Solanums* but from the product of selection by unknown breeders in ancient times. In other words, most of our modern potato varieties have been bred from the cultivated Indian varieties which possess 48 chromosomes and are classified as *Solanum tuberosum*. Correll (2) in his recent monograph dealing with the description and classification of *Solanum* species makes the following statement in regard to this important species: "As *S. tuberosum* apparently has never been found in a wild state (at least not in modern times), it is highly probable that this plant, as the civilized world has known it under cultivation, never occurred as such in nature." There is a good possibility that unknown breeders of hundreds and perhaps even thousands of years ago developed the cultivated 48 chromosome *S. tuberosum* from species hybrids. If such is the case, it is not surprising that the potato breeders of the ancient peoples of the Americas did not include in their cultivated varieties of *S. tuberosum* genes for many economic characters which we now find highly desirable in the varieties used in our intensified potato growing operations.

Characters such as immunity to late blight caused by *Phytophthora infestans* (Mont.) D By., and immunity to several serious virus diseases not found in *S. tuberosum* have been reported in a number of wild species of *Solanum*. The problem of combining highly desirable characters from the wild species with the large number of characters of economic importance in our modern potato varieties is exceedingly difficult.

Some species hybridization studies were made during the second half of the nineteenth century. These early studies were limited in scope. The first substantial contributions dealing with *Solanum* species hybrids were made during the first two decades of the present century by Salaman working in England and by Broili and Muller in Germany.

[1]Accepted for publication August 20, 1953.
Contribution from the Wisconsin Agricultural Experiment Station. Paper No. 524 from the Department of Genetics.

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These investigators were interested in incorporating the immunity to late blight found in *S. demissum* into acceptable horticultural varieties of *S. tuberosum*. It should be mentioned that prior to the time when they started their work only a small number (4 to 30) of tuber-bearing species of *Solanum* were recognized, and living collections of these wild species were not readily available to research workers. Similar work was begun in the nineteen twenties by Reddick at Cornell University. Reddick also placed special emphasis on *S. demissum* hybrids. He found it desirable to make a collecting trip to the plateau regions of Mexico during the course of his investigations in order to obtain additional stocks of wild tuber-bearing *Solanum* species immune to late blight. A dozen or more potato breeding laboratories located in various parts of the United States and Canada and many more laboratories located in foreign countries are at the present time using late blight resistant varieties and parental stocks developed by means of species hybrids at the four pioneer laboratories located at Cambridge, England; Dahlem, Germany, Ithaca, New York and Edinburgh, Scotland.

Search for New Genes of Economic Importance

The job of improving our potato varieties by means of species hybridization has only begun. The more difficult tasks and significant accomplishments of an enduring nature lie before us. The number of tuberous *Solanums* can only be estimated. New tuber-bearing species are found by capable plant explorers on each expedition to the native home of the potato. Approximately 200 wild species and 20 cultivated species are now recognized. According to Hawkes (3) and Correll (1), who have made recent potato collecting trips, at least three or four times the number of wild species mentioned are yet to be discovered and described. The wealth of this kind of material now on hand and the unknown stocks still to be found in the more isolated and inaccessible regions of Mexico, Central America and the South American Andes is a challenge to the ingenuity and industry of our modern scientific agriculture in the interests of improving one of our most important food crops. We are in the process of organizing an intelligent approach to the problem. A brief review of the essential activities and programs follows:

1. *Organized Plant Exploration and Collecting Expeditions*

The United States was one of the first countries to send an organized collecting expedition to South America in search of tuber-bearing *Solanums*. Dr. W. F. Wight made extensive collections in Peru, Bolivia and Chile in 1913. Two Russian expeditions came to the New World in 1925 and 1927 under the able leaderships of Bukasov and Juzepczuk. They discovered approximately 18 new cultivated and 30 wild species in Mexico, Central and South America. The practical implications of these expeditions prompted the governments of Sweden, Germany, Russia, the British Commonwealth and the United States to send additional organized collecting trips to the native home of the potato during the period 1930 to 1947.

Potato Collecting Expeditions Sent to
Mexico, Central and South America

Expedition	Leader	Date
American	Wight	1913
Russian	Bukasov	1925
Russian	Juzepczuk	1927
American	Reddick and Erlanson	1930
Swedish	Nordenskiold	1931
German	Baur and Schick	1931
American	Erlanson and MacMillan	1932
Russian	Vavilov and Kesselbrenner	1932
Swedish	Hammarlund	1934
British	Balls and Hawkes	1938
American	Correll	1947

These expeditions have been led by experienced and well trained botanists who were willing and able to work and travel for months at a time under the most rugged and primitive conditions to be found anywhere in the world. Additional potato collecting expeditions have been recommended by the plant explorers listed above. They are of the opinion that many valuable new species and varieties are yet to be discovered in the vast wild potato growing areas which lie in the thinly populated and inaccessible mountainous country ranging from Mexico southward through the Andean regions of South America.

2. *Identification and Systematic Classification*

The systematic classification of the tuberous species of *Solanums* has remained a perplexing problem for more than 100 years. In a recent monograph Correll (2) deals in detail with some of the taxonomic difficulties which exist in the tuber-bearing species in the section Tuberarium of the genus *Solanum*. Correll's valuable monograph dealing with the description and classification of 50 species and varieties of tuberous *Solanums* found in North and Central America has already become a standard reference for workers interested in species hybrids. A similar monograph dealing with the description and classification of the more numerous species and varieties found in South America would greatly add to essential knowledge and it would tend to reduce the confusion which now hampers research work with this important group of plants.

The identification and systematic classification of *Solanum* species should improve with the availability of extensive living potato collections and herbarium specimens such as are now being maintained in America and in several foreign countries.

3. *Plant Quarantine*

All potato tubers entering the United States from foreign countries except Canada, for propagation purposes, are examined by the Division of Entomology and Plant Quarantine, United States Department of Agriculture for plant diseases and insect pests. Tubers of foreign origin are grown in quarantine greenhouses at the United States Plant Introduction Garden, Glenn Dale, Maryland. The tuber crops from these greenhouse-grown plants which pass inspection are made available to research laboratories. True seeds are given a surface disinfection treatment before they are released for distribution. This valuable service is designed to keep out potato diseases and insect pests which do not occur in the United States. (Figure 1.)

4. *Maintenance and Preliminary Evaluation of a World-Wide American Potato Collection*

The Division of Plant Exploration and Introduction, United States Department of Agriculture has performed a most useful and essential service to potato improvement in this country by making available many thousands of seedling varieties and species from foreign lands. This division of the federal government organized and sponsored the four American potato-collecting expeditions previously mentioned. The Division of Plant Exploration and Introduction in cooperation with the federal Division of Vegetable Crops and Diseases and State Agricultural Experiment Stations has also brought into this country numerous *Solanum* species and varieties of potatoes through its foreign plant exchange service. It is reasonably certain that the now well known and valuable W-race of potato isolated by K. O. Muller, which appears in the pedigrees of 20 of the 41 varieties listed in table 1, was originally collected by the Division of Plant Exploration and Introduction.

A large reservoir of potato germ plasm from all parts of the world is now being maintained at the Inter-regional Potato Introduction Station, at Sturgeon Bay, Wisconsin. (Figure 2.) This station was organized in 1948 and receives its support from the Division of Plant Exploration and Introduction and the 48 State Agircultural Experiment Stations. The purpose of the introduction station is to make valuable disease-free species and parental stocks readily available to potato breeding and research programs throughout the nation. Cooperative exchange relations are maintained with similar stations located in foreign countries. Special mention should be made of the Commonwealth Potato Station in England and the Max-Planck Institut in Germany, which have supplied our station with a considerable number of outstanding disease-resistant potato species and parental stocks.

5. *Utilization of Wild and Cultivated Species in Breeding*

In exploring the possible utilization of the species that have been collected, it is first necessary to determine whether they can contribute characters of potential economic value. The full range of the plant science disciplines is required in the development of superior potato varieties at this point in the program. Adequate screening tests are necessary to determine the presence of plant characters affecting resistance to specific diseases and insects, market and table quality, handling, processing,

FIGURE 1.—Tuber-bearing species of *Solanum* growing in qaarantine at the United States Plant Introduction Garden, Glenn Dale, Maryland. These wild potatoes were collected by D. S. Correll of the Division of Plant Exploration and Introduction.

storage, yield, maturity and adaptation to particular locations. Refined scientific screening tests to detect such characters are now in progress or are being developed in the laboratories of the United States Department of Agriculture, State Agricultural Experiment Stations and in universities and agricultural institutions in America and abroad. Testing the species themselves may not be sufficient in all cases to establish their breeding value. An examination of their hybrids with *S. tuberosum* and their immediate progenies is necessary to obtain a proper evaluation. A second requirement is the development of suitable methods of transferring the

TABLE 1.—*Varieties of potatoes known to have been derived from species hybrids in 5 countries — 1953.*

Variety	Species Used	Year Introduced	Maturity	Yield	Starch Content	Late Blight	Scab	Viruses: Leafroll	Viruses: A	Viruses: X	Viruses: Y	Breeder
BRAZIL	(Guimaraes)											
Petrolini X-112	W-race	1952	M. early	High		Res. (com.)						Guimaraes
CANADA	(Young)											
Canso	*demissum*	1951	Late	High	High	Res.	Susc.	Susc.		F. res.	Susc.	Young
Keswick	*demissum*	1951	M. late	High	High	Res.	Susc.	Susc.		Susc.	Susc.	Young
GERMANY	(Rudorf)											
Robusta	W-race	1941	Med.	Med.	High	Res. (com.)	Med.	Res.				V. Pfetten
Fruhnudel	W-race	1941	M. early	High	Med.	Res. (com.)	Susc.	Susc.				Knehden
Erika	W-race	1941	Late	High	Med.	Res. (com.)	Med.	Susc.				Ragis
Roswitha	W-race	1942	Late	Med.	High	Res. (com.)	Med.	Res.				Sigl
Aquila	W-race	1942	M. late	High	High	Res. (com.)	Med.	V. res.			Res.	V. Durkheim
Falke	*demissum*	1943	Late	Med.	High	Res.	Res.	Res.			Res.	V. Moreau
Capella	W-race	1944	Late	High	Med.	Susc.	Med.	Res.			Susc.	Lembke
Panther	W-race	1945	Late	High	High	Res. (com.)	Res.	Res.			V. sus.	V. Moreau
Urtica	W-race	1946	M. late	Med.	High	Res.	Res.	Susc.			Res.	V. Kameke
Maritta	W-race	1947	M. late	V. high	High	Res. (com.)	Med.	Res.			V. res.	V. Zwehl
Jacobi	W-race	1947	Early	V. high	Med.	Res. (com.)	Med.	Res.			Susc.	V. Pfetten
Cornelia	W-race	1948	M. early	V. high	High	Res. (com.)	Susc.	Res.				Paulsen & Holscher
Forelle	W-race	1950	Early	V. high	High	Res. (com.)	Med.	Res.			Res.	V. Moreau
Fortunia	*andigenum*	1950	M. late	Med.	V. high	Med. res.	Med.	Res.			Res.	MPI and Asche
Virginia	*demissum*	1950	M. late	V. high	Med.	Med.	Susc.	Res.			Res.	MPI and Ragis
Adelheid	W-race	1950	Late	High	High	Res. (com.)	Susc.	Res.			Susc.	V. Zwehl
Benedikta	W-race	1951	M. late					Res.				V. Pfetten
Augusta	W-race	1951	M. early					V. res.				Ebstorf
Apta	W-race	1951	M. late					V. res.				Raddatz

SCOTLAND	(Black)											
Dr. McIntosh	Rybinii	1944	Med.	High		Susc.	Med.	Susc.	F. im.		Med.	McIntosh
Craigs Snow-White	*commersonii* *demissum* *maglia* *edinense*	1947	M. late	High		Res. com.	Med.	Med.	F. im.	F. im.	Susc.	SSRPB (Black)
Orion	*demissum*	1947	Med.	High		Res. com.	Med.	Med.		Susc.	Med.	McIntosh
Pentland Ace	Rybinii *demissum*	1951	M. early	High		Res. com. & B	Med.	Susc.	F. im.	F. im.	Med.	SSRPB (Black)
UNITED STATES												Reddick
Empire	*demissum*	1945	Late	High	High	Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Placid	*demissum*	1946	Med.	High		Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Virgil	*demissum*	1946	Late	High		Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Ashworth	*demissum*	1946	Med.	High		Res. com.	Susc.	Susc.			Susc.	Reddick
Chenango	*demissum*	1946	Early	High	High	Res. com.	Susc.	Susc.			Susc.	Reddick
Glenmeer	*demissum*	1946	V. late			Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Essex	*demissum*	1947	Early	V. high	Low	Res. com.	Susc.				Susc.	Reddick
Madison	*demissum*	1947	Med.			Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Snowdrift	*demissum*	1947	Early	High		Res. com.		Susc.			Susc.	Reddick
Cortland	*demissum*	1947	Late	Med.		Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Fillmore	*demissum*	1947	Late	High		Res. com.	Susc.	Susc.		Susc.	Susc.	Reddick
Harford	*demissum*	1947	Late	High		Res. com.	Susc.	Susc.				*demissum*
Kennebec	W-race	1948	M. late	V. high	High	Res. com.	Susc.	Susc.	Res.	Susc.	Susc.	Stevenson
Pungo	W-race	1951	Med.	High	High	Res. com.	Res.	Susc.	Res.	Susc.	Susc.	Stevenson
Cherokee	W-race	1951	Med.	High	High	Res. com.	Susc.		Res.	Susc.	Susc.	Stevenson

W-race — Derived from K. O. Muller
Susc. — Susceptible
Res. — Resistant
Im. — Immune
M. & Med. — Medium
V. — Very
F. — Field

MPI — Max-Planck-Institut
SSRPB — Scottish Society for Research in Plant Breeding
Com. — Common strain of late blight
(Com.) — Like Aquila
B — Resistant to Black's B strain of late blight

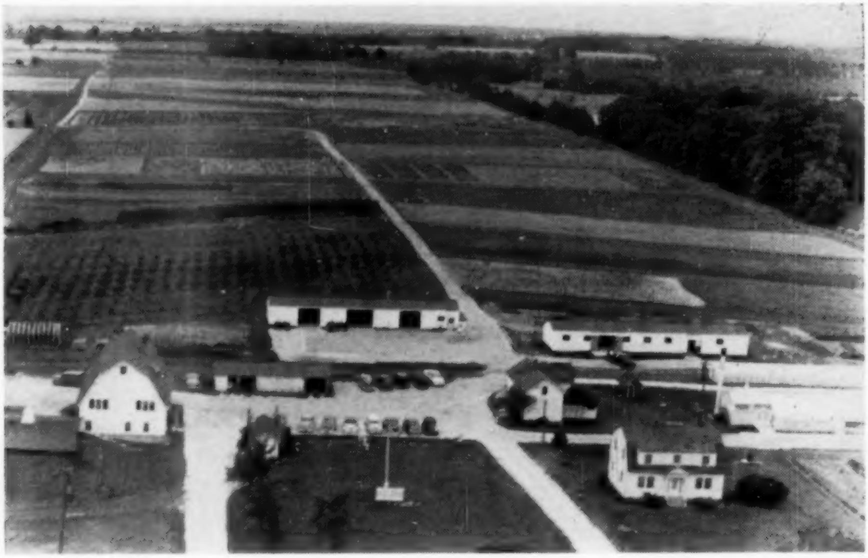

FIGURE 2.—The Inter-regional Potato Introduction Station, Sturgeon Bay, Wisconsin. Several thousand wild and cultivated species and varieties from many parts of the world make up a living germ plasm bank which is maintained as breeding stock for the improvement of potato varieties.

characters which exhibit economic potentialities in wild or cultivated species to commercial varieties of *S. tuberosum*. A knowledge of the cytogenetic relationships between the species and *S. tuberosum* is necessary to formulate a rational approach to these problems.

6. *Crossability and Cytogenetic Relationships*

Smith (5) found that the tuber-bearing *Solanum* species fall into different chromosomal groups, which constitute a polyploid series. The chromosome numbers that were recognized by him and Rybin were $2n = 24, 36, 48, 60$ and 72. South American cultivated varieties are found among the first four chromosomal groups but of these *S. tuberosum* which has 48 chromosomes is the only cultivated species used in the United States and Europe. Various methods are now in use or are being developed to overcome problems of incompatibility arising from different chromosome number relationships. They can be briefly summarized as follows:

(a) The Diploid Species with 24 Chromosomes:

Two methods have been used successfully in crossing this group of species with our commercial varieties which have 48 chromosomes. The first method involves direct hybridization which is made possible by the functioning of a certain proportion of unreduced gametes formed by the diploid species. A second and more positive method involves doubling the chromosome number of the diploid species by the colchicine treatment before attempting the cross. The resulting tetraploid plants possessing 48 chromosomes can be readily crossed with our commercial varieties.

(b) The Triploid Species with 36 Chromosomes:

The triploids ($2n \doteq 36$) are pollen and ovule sterile. Production of amphidiploids ($2n = 72$) by doubling the chromosome number often aids in restoring fertility according to Swaminathan (6).

(c) The Tetraploid Species with 48 Chromosomes:

Doubling the chromosome number of the maternal parent usually aids in surmounting sterility barriers in this group of plants according to Swaminathan (6). Embryo culture techniques are also being used.

(d) The Pentaploid Species with 60 Chromosomes:

Pentaploids ($2n = 60$) are difficult to use since their viable gametes usually contain varying chromosome numbers. Selecting the desirable offspring in crosses between these species and *S. tuberosum* and then backcrossing them to the commercial varieties is the normal procedure.

(e) The Hexaploid Species with 72 Chromosomes:

S. demissum is the only hexaploid ($2n = 72$) species known so far. Several commercial varieties have been produced by crossing this species with *S. tuberosum* followed by a few (3 to 5) generations of backcrossing. Work conducted by Howard and Swaninathan (4) shows that the pentaploid F_1 hybrid from the cross *S. demissum* x *S. tuberosum* forms on an average 24 bivalents + 12 univalents at metaphase during the first meiotic division, the univalents create complications in segregation. The univalents can be eliminated by continued backcrossing and selecting for. the desired type. Where, however, the factors required for introduction into a commercial variety are carried on a univalent, such a method would defeat its own ends. Black attempted to avoid or to minimize univalent formation by so arranging crosses that progeny of even chromosomal numbers are obtained. Therefore, he first crossed the diploid species *S. Rybinii* ($2n = 24$) with *S. demissum* ($2n = 72$) and then the resulting tetraploid ($2n = 48$), a hybrid, was crossed with *S. tuberosum* ($2n = 48$). The variety Pentland Ace was evolved in this manner as one will note in table 1.

We have no means at present to overcome sterility factors acting on the developing zygote after the effects of chromosome unbalance have been dealt with. Howard and Swaminathan (4) have suggested that multiple crosses will be of use in such cases.

Lastly, it is important that we have information concerning the chromosome structure relationships among the wild species and *S. tuberosum*, since these will have great bearing on the breeding methods adopted. Such studies are now in progress by Swaminathan (7) and before long we hope to have useful information concerning the nature of differentiation among *Solanum* species.

Accomplishments with Species Hybrids

An attempt has been made to develop a complete list of all varieties of potatoes derived from species hybrids. This has been accomplished by reviewing published articles and by writing to investigators located in the countries where potato breeding programs are in progress. Reports have been received from the thirteen countries listed in tables 1 and 2.

TABLE 2.—*Species hybrids of potatoes utilized in 13 countries.*

Country	Number of Varieties Developed from Species Hybrids	Species Hybrids Now Used in Breeding Programs	Number of Varieties Developed from Species Hybrids Available Commercially	Reported by[1]
Australia	0	+	1	E. C. Powell
Belgium	0	+	2	N. Rigot
Brazil	1	+	1	Floriano F. Guimaraes
Canada	2	+	3	L. C. Young
Denmark	0	+	?	Borge Jacobsen
England	0	+	4	H. W. Howard
Germany	19	+	19	Wilhelm Rudorf
Holland	0	+	?	H. J. Toxopeus
India	0	+	0	M. S. Swaminathan
Norway	0	+	few	Aksel P. Lunden
Scotland	4	+	4	W. Black
South Africa	0	+	2	J. E. Van der Plank
United States	15	+	17	R. W. Hougas

[1]The authors wish to express their appreciation for the information provided by these investigators.

The following five countries have developed named varieties of potatoes containing germ plasm other than that of *S. tuberosum*:

Brazil
Canada
Germany
Scotland
United States

The remaining eight countries listed below have not developed named varieties from species hybrids but are using germ plasm other than *S. tuberosum* in breeding programs at the present time:

Australia	Holland
Belgium	India
Denmark	Norway
England	South Africa

It is of interest to note that the 41 varieties obtained from species hybrids presented in table 1, have been named and made available to the trade during the past thirteen years. Most of the varieties have been released because they show varying degrees of resistance to physiologic races of *Phytophthora infestans*. The late blight resistance found in most

of the varieties was obtained from *S. demissum* or the Muller W-race which is also believed to be of *S. demissum* origin. No named commercial variety has been reported to be immune to all the races of *P. infestans* known at present. However, there are favorable indications that commercial varieties with desirable horticultural characters and immunity to most, if not all, of the known races of the late blight fungus can be produced. There are varieties of *S. demissum* and several other species of *Solanum* which have been tested under a wide range of conditions over a period of years and have remained resistant to all known races of the causal organism.

Three fourths of the varieties developed from species hybrids are reported to possess high or very high yielding ability. These results agree with the experience with other crop plants where species hybrids have been used in variety improvement. The marked increase in yielding ability associated with derivatives from species hybrids has been attributed to hybrid vigor. Toxopeus (8) found that *S. demissum* contributes not only genes for resistance to late blight but also for tuber yield in crosses with *S. tuberosum*.

High starch content is another important character found in approximately one-half of the varieties derived from species hybrids.

Kennebec is the most widely grown variety in North America which has been developed following hybridization with a wild species. At least 100,000 acres of this variety were grown in 1952. It produces large yields of tubers of high starch content. Kennebec potatoes are exceptionally desirable for the manufacture of potato chips.

There has been a gradual but steady increase in the use of species hybrids in potato breeding programs. The importance attached to a number of economic characters found in some of the wild species and not to be found in *S. tuberosum* indicates that the number of new improved commercial varieties derived from species hybrids will be greatly increased in the future.

Literature Cited

1. Correll, D. S. 1948. Collecting wild potatoes in Mexico. U. S. Dept. of Agr. Circ. No. 797. 40 pp. illus.
2. ————. 1952. Section *Tuberarium* of the genus *Solanum* of North America and Central America. U. S. Dept. of Agr. Monograph No. 11. 243 pp. illus.
3. Hawkes, J. G. 1944. Potato collecting expeditions in Mexico and South America. II Systematic classification of the collections. Imperial Bureau of Plant Breeding and Genetics, Cambridge. 142 pp.
4. Howard, H. W. and M. S. Swaminathan. 1952. Species differentiation in the section *Tuberarium* of *Solanum* with particular reference to the use of interspecific hybridization in breeding. Euphytica 1: 20-28.
5. Smith, H. B. 1927. Chromosome counts in the varieties of *Solanum tuberosum* and allied wild species. Genetics 12: 84-92.
6. Swaminathan, M. S. 1951. Notes on induced polyploids in the tuber-bearing *Solanum* species and their crossability with *Solanum tuberosum*. Amer. Potato Jour. 28: 472-489.
7. ————. Studies on inter-relationships between taxonomic series in the section *Tuberarium*, genus *Solanum*. I *Commersonia* and *Tuberosa*. (In press.)
8. Toxopeus, H. J. 1952. Over de Mogelijke beteknis van *Solanum demissum* voor de Veredeling gericht op verhoging van de Knolopbrengst. Euphytica 1: 133-139.

BRANCH-TRACE NECROSIS, A SYMPTOM OF POTATO LEAFROLL VIRUS INFECTION[1]

JOHN J. NATTI[2] AND A. FRANK ROSS[3]

A rapid dependable method for detecting potato plants infected with potato leafroll virus would be of considerable value to the potato breeder and to the grower of seed potatoes. Detection of infected plants by observation of external symptoms, the usual method of diagnosis, is rapid but frequently the symptoms are not sufficiently distinct for accurate diagnosis. The need for a dependable method of leafroll diagnosis led to the introduction of the phloroglucinol test by Quanjer (5). Although other investigators (1, 6, 7) have reported favorably on its accuracy, the phloroglucinol test is not used by growers, probably because it is not readily adaptable for rapid diagnoses under field conditions.

Necrosis of the internal phloem of the branch-traces, a previously undescribed symptom of leafroll observed in potato plants grown in the greenhouse, provided a means for rapid diagnosis of leafroll in certain varieties of potatoes. Although all infected plants were not detected, results from the use of this symptom for leafroll diagnosis in the greenhouse were comparable to those obtained from the use of the phloroglucinol test and superior to those from the use of external symptoms.

DESCRIPTION OF BRANCH-TRACE NECROSIS IN THE VARIETY KATAHDIN

Experimentally infected plants and plants grown from leafroll virus-infected tubers were used. All plants were grown in the greenhouse from March through May in composted soil in 4-inch pots. The greenhouse temperatures were maintained at 65 to 75° F., except for occasional days when the temperature rose as high as 90° F. The chronically infected plants were examined for branch-trace necrosis when they had attained a height of 18 to 24 inches. The experimentally infected plants were inoculated when they were about 12 inches in height and were examined for branch-trace necrosis 40 days after inoculation.

The necrosis was revealed either by severing a stem across a node or by removing a series of free-hand cross-sections from a node in such a manner that the two branch-traces which extend into an axillary bud were exposed. The necrotic areas were visible to the unaided eye so that no special equipment or treatment of tissues was necessary.

Chronic Infection. In stems severed across a node, necrosis of the branch-traces was visible as two small dark-brown areas separated by the pith of the axillary bud and corresponding in location to that of the two branch-traces extending into the bud. The necrotic areas were most conspicuous toward the base of the bud in the region adjacent to the xylem of the main stem (Fig. 1, 3). The largest necrotic areas were

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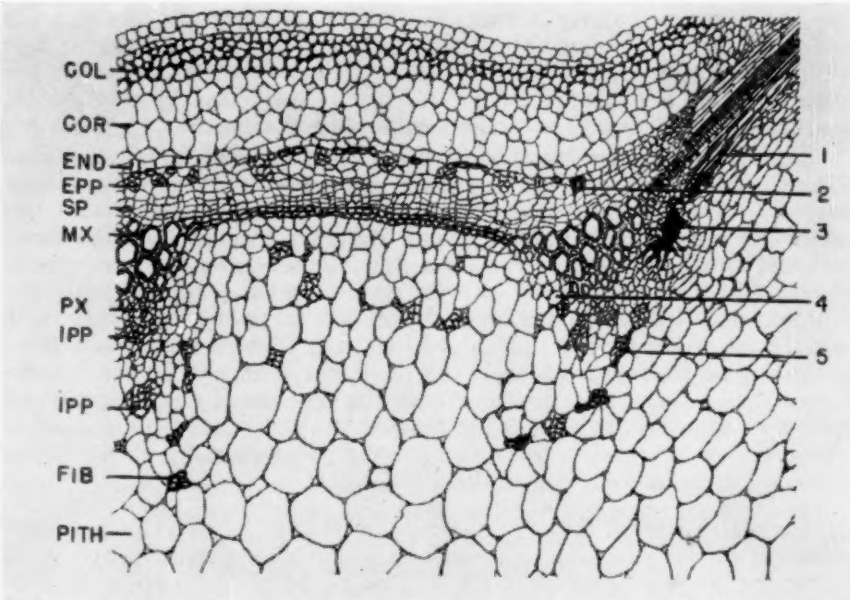

FIGURE 1.—Cross-section through node of potato plant of the variety Katahdin infected with potato leafroll virus.

COL — Collenchyma
COR — Cortex
END — Endodermis
MX — Metaxylem
PX — Primary xylem
EPP — External primary phloem
IPP — Internal primary phloem
SP — Secondary phloem
FIB — Fibers

1. Necrosis extending along phloem of branch trace
2. Necrotic external primary phloem cells
3. Necrotic area in internal phloem of branch-trace
4. Necrotic parenchymatous cells
5. Necrotic internal primary phloem cells in main stem.

approximately 1 mm. in diameter in basal nodes but their size gradually diminished toward the apex of the plant. The necrosis occasionally extended from the branch-traces for a short distance into the adjoining primary vascular tissue in the main stem, but generally was restricted solely to the branch-traces. Consequently, care had to be taken to expose the branch-traces when examining plants for the symptom.

In cross-sections examined with the aid of a microscope, the necrotic areas were observed to be restricted to the internal phloem of the branch-traces. These necrotic areas consisted of phloem cells at various stages of disintegration. The margins of these areas were composed of contiguous phloem cells, the walls of which were intact although brown and thickened. Many of the cells were filled with a dark amorphous substance. Toward the center of the necrotic area, the walls of the phloem cells had disintegrated to form a lysigenous cavity which was filled with this dark substance. The more or less radial arrangement of parenchymatous cells at the periphery of the necrotic area indicated that the necrosis had been initiated early in the development of the branch-trace.

The necrosis frequently involved most of the internal phloem in the portion of the bud beyond the point at which the two branch-traces fuse to form the stele of the axillary bud. Consequently, in cross-sections through the middle portion of a bud, the necrosis usually was evident as a narrow band of necrotic cells surrounding the pith.

Branch-trace necrosis was more severe in nodes from the lower portion of the plant than in those from the apical portion. In nodes from the lower part of the plant, the necrotic areas were visible to the unaided eye and did not react with phloroglucinol, differing in these respects from the usual type of phloem necrosis described as occurring in potato plants infected with leafroll virus (1, 5). In nodes from the upper half of the plant, necrosis frequently was not evident but when sections from these nodes were treated with phloroglucinol and then examined with a microscope, a reaction with phloroglucinol was observed in the branch-traces. These observations indicated that the necrosis of the branch-traces which is visible to the unaided eye most probably represented a more advanced type of phloem necrosis than that which occurs in the stems of potato plants infected with leafroll virus.

Current Season Infection. Necrosis of phloem of branch-traces was present in potato plants experimentally infected with potato leafroll virus during the current growing season. This necrosis was similar to that observed in chronically infected plants, but was restricted to the apical portion of the inoculated stems except for the uppermost three or four nodes. Branch-traces of axillary buds of lateral branches developing from plants infected during the current season also exhibited necrosis. The location of the necrotic branch-traces of the lateral branches varied with the stage of development of the branch at the time of invasion by the virus. If invasion occurred during bud stage, the necrosis was found in the lower nodes of the branch. If the branch had made considerable growth before invasion, the necrosis was present either in the middle portion or in the apical portion of the branch.

Diagnostic Value of Branch-Trace Necrosis

Preliminary experiments had indicated that potato plants of the variety Katahdin and the seedling Colorado 6332 infected with potato leafroll virus exhibited conspicuous necrotic areas in the region of the branch-traces. Consequently, plants of this variety and of this seedling were used in tests to determine the value of these necrotic areas for the diagnosis of potato leafroll. The potato plants were grown in composted soil in 4-inch pots in the greenhouse maintained at temperatures of 65° F. to 75° F. Each plant originated from a single seedpiece removed from a tuber obtained from a sample containing an unknown number of tubers infected with potato leafroll virus. Each plant was judged infected or non-infected according to each of four methods of diagnosis. These methods in the order of their application were (a) observation of external symptoms, (b) observation of branch-trace necrosis, (c) observation of phloem necrosis by means of the phloroglucinol test, and (d) transmission of the virus by aphids from potato plants to leafroll indicator plants.

Diagnoses by observation of external symptoms were conducted in

the greenhouse when the plants had attained a height varying from 18 to 24 inches. Each plant was observed for symptoms characteristic of leafroll, *e.g.*, rolling and leathery texture of leaves; erect, rigid aspect of the plant; and dwarfing.

Diagnoses by observation of branch-trace necrosis were carried out in the laboratory instead of the greenhouse in order that the plant material used in this method of diagnosis could also be used in the phloroglucinol test. A single stem from each plant in the greenhouse was severed between the basal and second node and brought into the laboratory. A series of thin free-hand cross-sections were removed from the lower nodes of the stem. The sectioning was started at the base of the petiole and continued toward the axillary bud. The branch-traces were thus exposed and necrosis, if present, was visible.

Diagnoses by means of the phloroglucinol test were conducted in the laboratory. Thin free-hand cross sections from the lower nodes of each plant were placed in a 2 per cent phloroglucinol solution for 3 minutes and then in a 40 per cent sulfuric acid solution for 3 minutes. The concentration of the reagents were those recommended by Hutton (3). The treated sections were examined with the aid of a microscope at 120X. Plants were judged infected if the walls of some of the primary phloem cells were red to reddish-purple in color.

Diagnoses by transmission of the virus by aphids from potato plants to leafroll indicator plants were conducted in the greenhouse. Because the stem taken for laboratory examination had been severed at the first internode, a shoot grew from the basal node. This shoot was allowed to attain a length from 3 to 6 inches and then was infested with 20 to 30 wingless forms of the aphid, *Myzus persicae*, Sulzer, that had been proved non-viruliferous. The plants were caged immediately. After 7 days, five to seven aphids were transferred from each potato plant to each of 3 plants of *Physalis floridana* Rydberg. These potato leafroll indicator plants (4) were caged immediately after infestation with aphids. After 5 days, the aphids were killed by fumes of nicotine sulfate, the cages removed, and the indicator plants transferred to a greenhouse bench. These plants were observed over a period of 60 days for symptoms of leafroll.

Comparison of Methods of Diagnosis. The aphid transmission test was presumed to be the most accurate of the diagnostic methods employed. In no instance were plants diagnosed as healthy by the aphid transmission tests diagnosed as infected by the other tests. More plants were diagnosed as infected by the aphid transmission method than by any of the other methods as shown in table 1. On the basis of results obtained from the aphid transmission tests with the variety Katahdin, diagnosis by observation of branch-trace necrosis was equally as effective as the phloroglucinol test and more effective than diagnosis by external symptoms. With Colorado seedling 6332, diagnosis by observation of branch-trace necrosis was equally as effective as diagnosis by aphid transmission test or by the phloroglucinol test. Diagnosis by observation of external symptoms was less effective than by the other methods of diagnosis. The results indicated that diagnosis by observation of branch-trace necrosis was sufficiently accurate to justify the use of this symptom for diagnostic purposes, in varieties which exhibit branch-trace necrosis.

TABLE 1.—*Comparative results from four methods of potato leafroll diagnosis.*

Variety	No. Plants Tested (a)	Method of Diagnosis	No. Plants Diagnosed as Infected
Katahdin	103	Aphid transmission	24
		Branch-trace necrosis	20
		Phloroglucinol test	20
		External symptoms	16
Colorado Seedling 6332	78	Aphid transmission	39
		Branch-trace necrosis	39
		Phloroglucinol test	38
		External symptoms	23

(a) Each plant diagnosed by each method.

Varietal Differences. Under greenhouse conditions, branch-trace necrosis was conspicuous in infected plants of some varieties, but in other varieties this symptom was either less evident or absent. In the varieties Katahdin and Essex, conspicuous necrotic areas usually were present in all infected plants. In infected plants of the variety Sebago, branch-trace necrosis was readily observed, but the incidence of this necrosis in infected plants was not determined. Of 25 plants of the variety Kennebec experimentally infected with leafroll virus, 11 plants developed branch-trace necrosis visible to the unaided eye, whereas the remainder exhibited necrotic areas in the branch traces which were observed only with the aid of a microscope in tissues which had been treated with phloroglucinol. Infected plants of the variety Ontario exhibited no visible branch-tree necrosis, but the phloroglucinol test revealed that necrotic areas were present in the branch-traces. Infected plants of the varieties Green Mountain and Cobbler showed no branch-trace necrosis nor did the phloroglucinol test reveal any localization of necrosis in the branch-traces.

Under field conditions, all plants examined in the varieties Snowdrift and Chenango which exhibited external symptoms of leafroll showed branch-trace necrosis. Plants of these varieties which were judged healthy on the basis of external appearance did not exhibit branch-trace necrosis. In one field planting, plants of the variety Katahdin originating from infected tubers developed branch-trace necrosis. However, at another location, plants originating from tubers with at least a 3-year history of leafroll virus infection failed to exhibit branch-trace necrosis. Plants of the varieties Cobbler, Green Mountain, Kennebec, and Ontario which exhibited external symptoms of leafroll in the field failed to show necrosis of the branch-traces.

Discussion

Diagnosis of potato leafroll virus infection in certain varieties of potatoes by observation of branch-trace necrosis was sufficiently dependable in greenhouse tests, and so rapid, that further tests on its diagnostic

value should be conducted. Since no special equipment or treatment of tissues is necessary, this method of diagnosis should be readily adaptable to field conditions. However, the diagnostic value of branch-trace necrosis and the reaction of different varieties of potatoes to leafroll virus infection under field conditions needs to be determined before this method of diagnosis can be considered to be of practical value.

To be of diagnostic value, the necrosis of the branch-traces should be located in the internal phloem and should occur in a number of successive nodes. Although occasional potato plants infected with leafroll virus may show necrosis of external primary phloem cells of axillary buds, this location of necrosis is not sufficiently consistent for dependable diagnosis. Infection of axillary buds by potato viruses X and Y, singly or in combination, and injury caused by sprays, insects, or other agents may cause necrosis of cortical tissues which is not readily distinguishable from necrosis of the external phloem. Branch-trace necrosis caused by injury is usually confined to the node at the site of the injury, whereas necrosis caused by leafroll virus infection occurs in branch-traces of successive nodes.

Infected plants of the varieties Essex and Katahdin were observed to develop severe necrosis of the internal phloem of main stem as well as in the phloem of the axillary buds. These varieties also exhibit considerable field resistance to leafroll virus. This association of field resistance with susceptibility of the phloem to leafroll virus infection suggests the possibility that the field resistance attributed to these varieties may be caused by the severe reaction of phloem tissue to the virus. This severe reaction may tend to localize the virus injected by insects into some plants. Also, the necrotic reaction may result in restricted multiplication of the virus. If so, infected plants of these varieties would be poor sources of inoculum and secondary spread from such plants would be limited.

The fact that phloem necrosis is more advanced in branch-traces than in the main stem of potato plants chronically infected with leafroll virus (1, 5) does not appear to be due directly to the stage of tissue differentiation at time of invasion by the virus or to the duration of infection. Since the differentiation of tissues in both locations has taken place under conditions of systemic infection, the tissues in each location have been exposed to the virus during all stages of tissue development. According to Eames and MacDaniels (2), branch-traces are extensions of the primary vascular system of the main stem. Consequently, the duration of infection of the phloem of the branch-traces at a given node most probably is the same as that of the primary phloem of the main stem at the site of that node. The severe necrosis of the phloem in the branch-traces is apparently more likely to be caused by the combined effect of stage of differentiation of tissues at time of invasion by the virus and duration of infection than to the direct effect of each of these factors. Since branch-traces of axillary buds are largely in a procambial stage (2) and the development of axillary buds is slow in comparison to the growth of terminal buds, the extended exposure of tissues of axillary buds in early stages of differentiation to the virus may result in the severe necrosis observed in branch-traces.

According to Quanjer (5), the reaction of phloroglucinol with necrotic phloem cells of potato plants infected with leafroll virus indicates that

the walls of these cells have undergone lignification. Since the severity of necrosis of the phloem of the branch-traces ranged from slight necrosis characterized by phloem cells which reacted with phloroglucinol to an advanced form of necrosis in which the phloem cells had completely disintegrated, there is some doubt that leafroll virus infection results in the lignification of phloem cells. Lignin is a very stable product and it is improbable that virus infection can bring about disintegration of lignified tissues. It is more likely that the reaction of phloroglucinol with necrotic phloem cells indicates the presence of intermediary products released during the breakdown of phloem cells. These products probably have reactive groupings of similar structure to those of the lignin molecule which react with phloroglucinol.

Summary

In greenhouse tests, potato plants of the varieties Essex, Katahdin, and Sebago and seedling Colorado 6332 infected with potato leafroll virus developed conspicuous necrotic areas located in the branch-traces. These necrotic areas were visible to the unaided eye in untreated plant tissues. The necrosis represented a more advanced form of phloem necrosis than that previously described as associated with leafroll virus infection of potato.

In greenhouse tests, diagnosis of leafroll by observation of branch-trace necrosis in plants of the variety Katahdin and of the seedling Colorado 6332 was equally as effective as by the phloroglucinol test and more effective than diagnosis by observation of external symptoms. Only those plants from which the virus was transmitted to suitable indicator plants by means of aphids were judged to be infected.

Under greenhouse conditions, infected plants of the varieties Katahdin and Essex usually exhibited branch-trace necrosis visible to the unaided eye. Infected plants of the variety Sebago developed readily visible necrotic areas in the branch-traces, but the incidence of this symptom in infected plants was not determined. In the variety Kennebec, about one-half of the infected plants developed branch-trace necrosis. Infected plants of the varieties Cobbler, Green Mountain and Ontario did not exhibit branch-trace necrosis visible to the unaided eye.

Under field conditions, plants of the varieties Chenango and Snowdrift which were judged to be infected by means of external symptoms also exhibited branch-trace necrosis. Infected plants of the variety Katahdin displayed branch-trace necrosis in one planting but not in another planting originating from tubers with at least a 3-year history of leafroll virus infection. No branch-trace necrosis was observed in infected plants of the varieties Cobbler, Green Mountain, Kennebec and Ontario.

Diagnosis by observation of branch-trace necrosis is rapid and since no special equipment or treatments of tissues is necessary, this method of diagnosis should be readily adaptable to field conditions. The diagnostic value of branch-trace necrosis and the reaction of different varieties of potatoes under field conditions needs to be determined before this method of diagnosis can be considered to be of practical value.

Literature Cited

1. Artschwager, E. F. 1923. Occurrence and significance of phloem necrosis in the Irish potato. Jour. Agr. Res. 24: 237-246.
2. Eames, A. J. and L. H. MacDaniels. 1947. An introduction to plant anatomy. Second Edition, 427 pp., McGraw-Hill Book Company, Inc., New York and London.
3. Hutton, E. M. 1949. The significance of the necrotic phloem reaction in the potato to the leafroll virus. Austral. Jour. Sci. Res. Series B, Biol. Sci. 2: 249-270.
4. Kirkpatrick, H. C. 1948. Indicator plants for studies with the leafroll virus of potatoes. Amer. Potato Jour. 25: 283-290.
5. Quanjer, H. M. 1913. Die Nekrose des Phloems der Kartoffelpflanze, die Ursache der Blattrollkrankheit. Meded. Rijks. Hoogere Land-, Tuin-en Boschbouwschool (Wageningen) 6: 41-80.
6. Sheffield, F. M. L. 1943. Value of phloem necrosis in the diagnosis of potato leafroll. Ann. Appl. Biol. 30: 131-136.
7. Wilson, J. H. 1948. The use of the phloroglucinol test for diagnosis of leafroll in potatoes. Jour. Austral. Inst. Agr. Sci. 14: 76-78.

THE EFFECT OF SIZE OF TUBERS AND SEED PIECES IN WESTERN NEBRASKA DRYLAND POTATO CULTURE[1]

H. O. Werner[2,3]

Good stands of potato plants and the vigor of the early growth of the plants are influenced considerably by the extent of survival of the seed pieces after planting. This depends largely upon how well they are protected by an effective periderm (3). In seed pieces cut from tubers, the tissues nearest to the normal skin (periderm) or to vascular tissues develop a wound cork more quickly than do the parenchyma tissues in the central pith. (2), (3).

When seed pieces have two cut surfaces, the last area to heal is where the two surfaces meet, and with three cut surfaces the last portion to heal is at the juncture of the three surfaces. Frequently the healing of these areas is so slow or incomplete as to be ineffective against parasitic rot-producing organisms. In commercial practice the use of relatively small potatoes for seed purposes increases the probability of good stands because the smaller the seed tubers the less the area of cut surfaces in seed pieces of any given size and hence the less likelihood that they will rot partly or entirely.

Because of these various commercial aspects it was deemed advisable to determine the extent to which the size of the tubers influences stands and vigor of plants, tuber set and yield and size of tubers, when cut into seed pieces of different sizes and planted under the varying soil conditions that prevail in the dryland areas of western Nebraska.

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[3]The author acknowledges the cooperation of George Schmidt and Robert Pahl, supervisors of the Box Butte Experiment Farm, during the seasons 1937-1939 and 1940-1941, respectively.

The experiment to determine these facts was conducted on dryland at the Box Butte Experiment Farm as follows: The seed potatoes used were of certification quality of a clone of intermediate season. Tubers were sorted into five distinct size groups, as shown in table 1, with a deviation from the mean size of each group of not more than 10 per cent. The size groups differed sufficiently to provide large gaps between the tubers in the proximate extremes of adjacent size classes. These tuber sizes were arbitrarily chosen to permit pieces of uniform weight to be cut from tubers of all groups without discarding any portions of any tubers. The potatoes were cut one to four days in advance of planting. During this time they were held under proper conditions for wound cork formation in a humid potato cellar at a temperature of about 60°F. Four single row randomized plots of 110 hills each were planted from each treatment. Plant emergence counts were made at frequent intervals. Gross weights of all potatoes produced in each plot were obtained at harvest time. Several weeks after harvest the potatoes from the four plots of each treatment were sorted as a unit for size and grade.

Some of the most unfavorable weather conditions in the history of this area occurred during the years of this experiment. The rainfall in 1937, 1939, and 1940 was far below average.

TABLE 1.—*Sizes of tubers and seed pieces and stems produced per seed piece in various treatments in 1940 and 1941.*

Treatment Number	Approximate Weight of Seed Tubers Used; Grams	Number of Pieces out of Each Tuber	1940		1941	
			Mean Weight per Seed Piece; Grams	Mean Number of Stems from Each Seed Piece	Mean Weight per Seed Piece; Grams	Mean Number of Stems from Each Seed Piece
SMALL SEED PIECES						
9	30	One[1]	29.5	3.61	30.9	3.60
8	50	Two[2]	25.2	2.43	20.6	3.21
4	83	Four	20.9	2.93	18.8	2.57
5	136	Six	21.7	2.26	16.0	2.38
6	177	Eight	22.2	2.22	19.4	2.47
LARGE SEED PIECES						
7	50	One[2]	50.4	4.55	57.8	4.38
1	83	Two	41.8	3.54	36.5	3.97
2	136	Three	43.4	3.68	31.8	3.63
3	177	Four	44.3	3.27	36.6	3.43

[1]"C" size tubers — less than 1½ inch diameter.
[2]"B" size tubers — 1⅞ to 1½ inch diameter.

Experimental Results

The emergence rate was most rapid with the largest seed pieces from tubers of any given size and from the smallest tubers when seed pieces were uniform in size (Figure 1). Emergence rate data are shown for only one year because the relative relationship of the various lots was essentially the same in all years. Large seed pieces produced the best stands but with seed pieces of both sizes there was a steady decrease in final stands of plants as the size of the seed tubers increased, as one will note in figure 2. These differences were greatest in the years when soil conditions were least favorable at planting time *i.e.* temperatures were relatively high and soil moisture lacking.

The number of stems per seed piece increased as the weight of the seed pieces increased and also as the weight of the seed tubers decreased (Figure 3, Table 1).

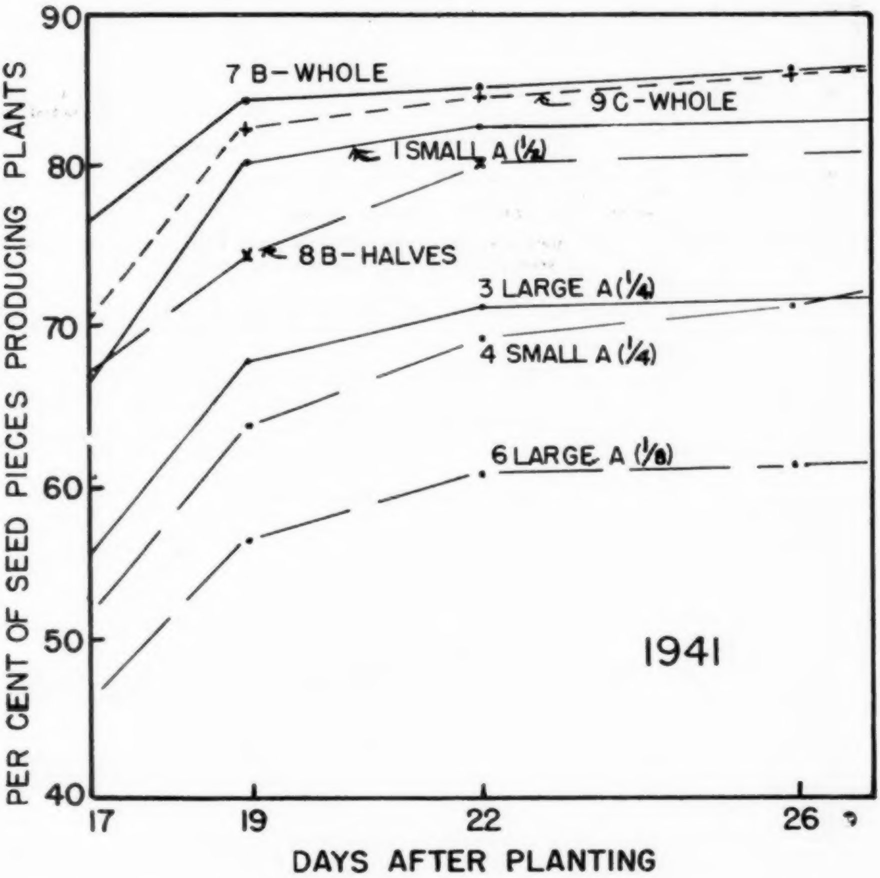

FIGURE 1.—Rate of plant emergence with seed pieces of two sizes derived from seed potatoes of various sizes. (For identification of treatments see table 1.) (4, 6, 8 and 9 approximately 20 gms., 1 and 3 — 30 gms., and 7 — 55 gms.)

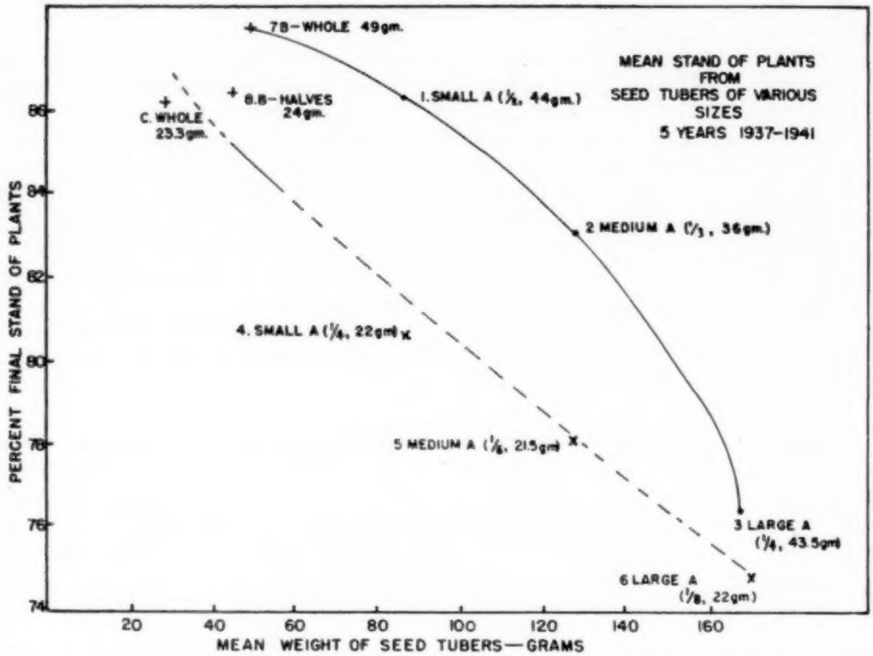

FIGURE 2.—Relation of seed tuber and seed piece sizes to final stand of plants. (Upper line, large seed pieces; lower line, small pieces.

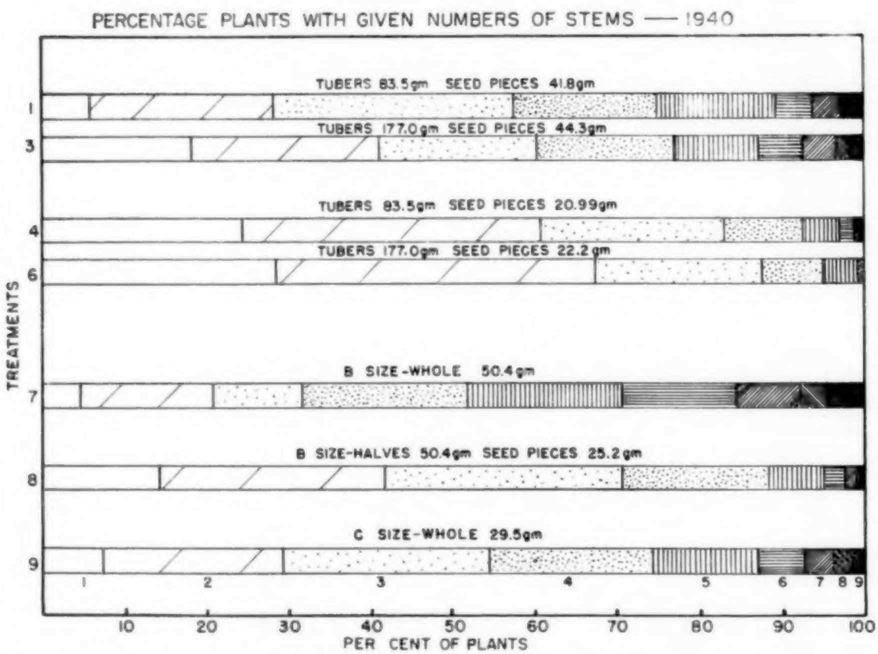

FIGURE 3.—Percentages of plants with various numbers of stems produced by tubers and seed pieces of various sizes.

The average yields throughout the five years were increased about ten bushels per acre by doubling the size of the seed pieces 22 to 44 grams as shown in figure 4. However, by decreasing the average size of the seed potatoes used from 155 grams to 28 grams (without altering seed piece size) the mean yields were increased approximately 12 bushels per acre. Therefore, the lowest average yields occurred when 155 gram tubers were cut into eight pieces and the highest when 50 gram tubers were planted whole. The C size (28 gram) tubers planted whole yielded more than 154 gram tubers cut into three pieces or at almost twice the rate per acre.

The net total yield after deducting the quantity planted increased steadily as the individual weights of the seed tubers decreased, as one will observe in figure 5. The extreme differences varied from 59.5 bushels per acre with large tubers cut into eight pieces averaging 22.1 grams

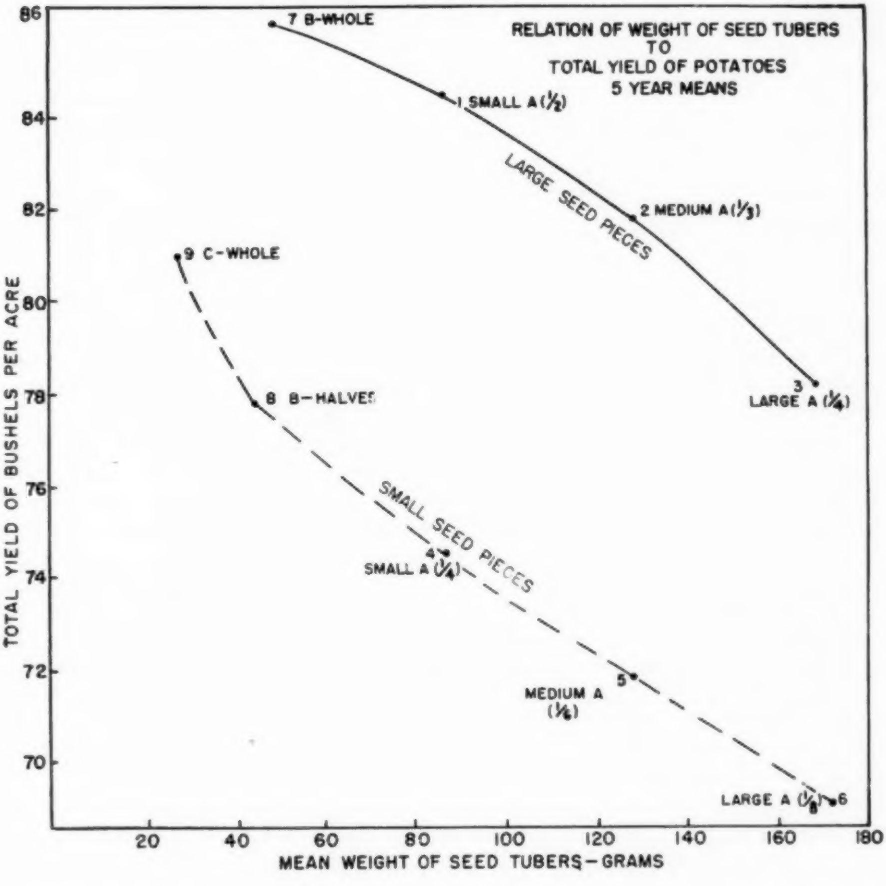

FIGURE 4.—Mean total yields produced by seed pieces of two sizes derived from seed potatoes of various sizes.

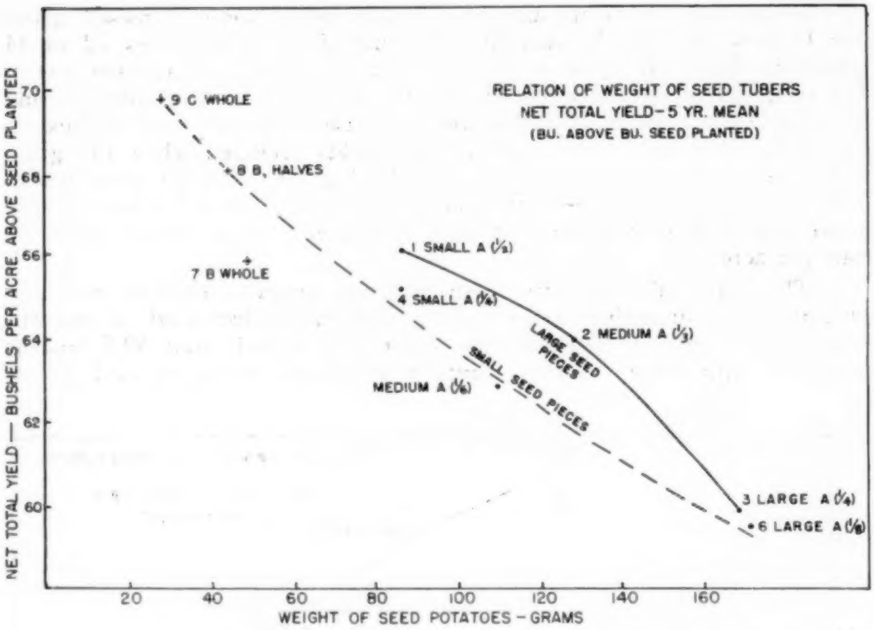

FIGURE 5.—Mean net total yield — above amount of seed planted, produced by seed pieces of two sizes derived from seed tubers of different sizes.

(treatment 6) to 69.9 bushels from C size tubers averaging 28.1 grams and planted whole (treatment 3). The net yield from large pieces was only slightly greater than from small pieces, except with B size tubers when halves netted more yield than whole tuber pieces (8B vs 7B).

The five-year mean total yields increased as the quantity of seed planted per acre increased as one will observe in figure 6. This was primarily caused by an increase in seed piece weight, but with both groups of seed piece sizes, the yields were greatest from the smaller tubers.

The effect of planting rate upon total yield per acre fluctuated seasonally. In seasons favorable for relatively high tuber production — as were 1938, 1939, and 1941, the total yield increased materially as the quantity of seed planted per acre was increased. In 1940 — a year of mediocre production, and 1937 — one of the poorest years on record, the quantity of seed planted had little influence on yield. Large seed pieces were responsible for most of these increases in yield, but with each seed piece size, yields were usually greatest when they were derived from the smaller tubers.

When cost of seed potatoes was a limiting factor it may not have been economical to plant large quantities of seed per acre, for throughout the five years more bushels per acre were produced per bushel planted with the smaller, than with the greater planting rates, as shown in figure 7. In the least favorable years for tuber production there was no advantage in planting large quantities of potatoes to the acre.

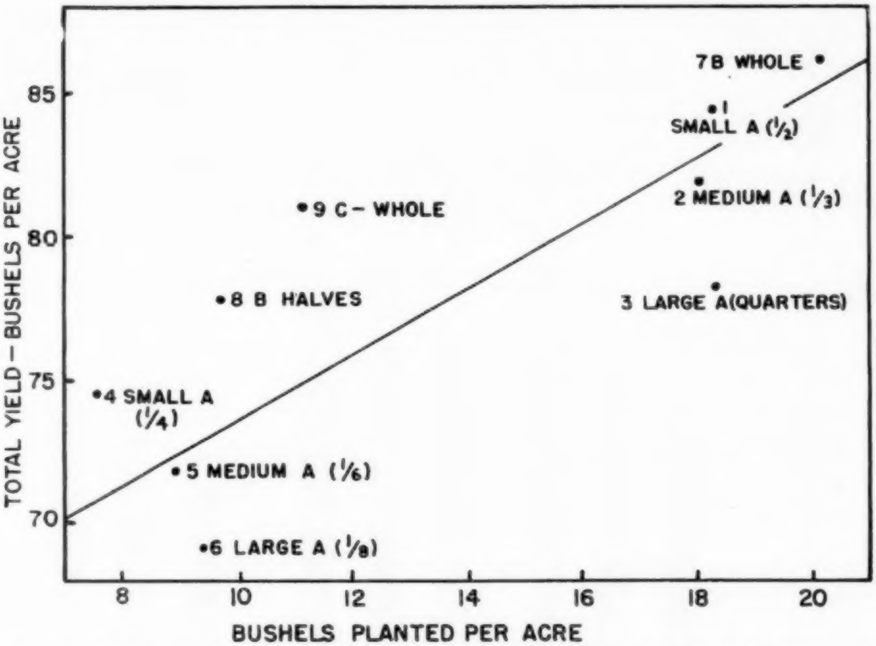

FIGURE 6.—Mean total yield in bushels per acre for each bushel planted when seed pieces of two sizes were derived from seed potatoes of various sizes. (Group at left, small pieces; at right, large pieces.)

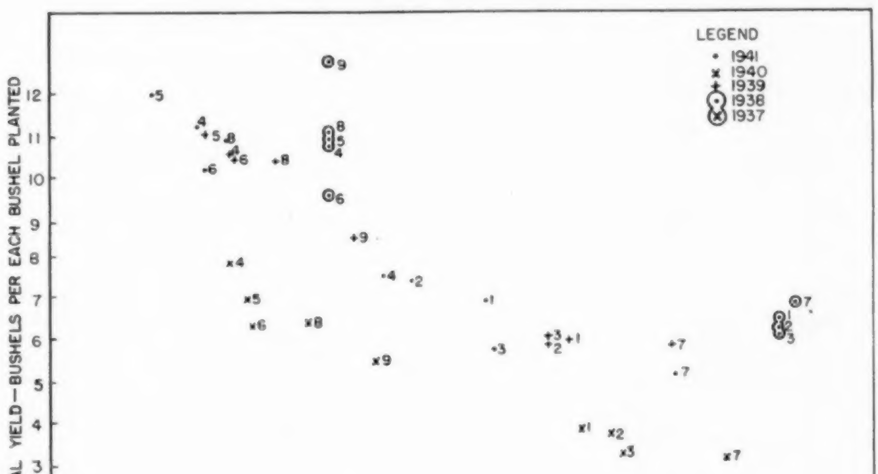

FIGURE 7.—Distribution of total yield per acre produced for each bushel planted when using two seed piece sizes and seed potatoes of several sizes, in each of five years.

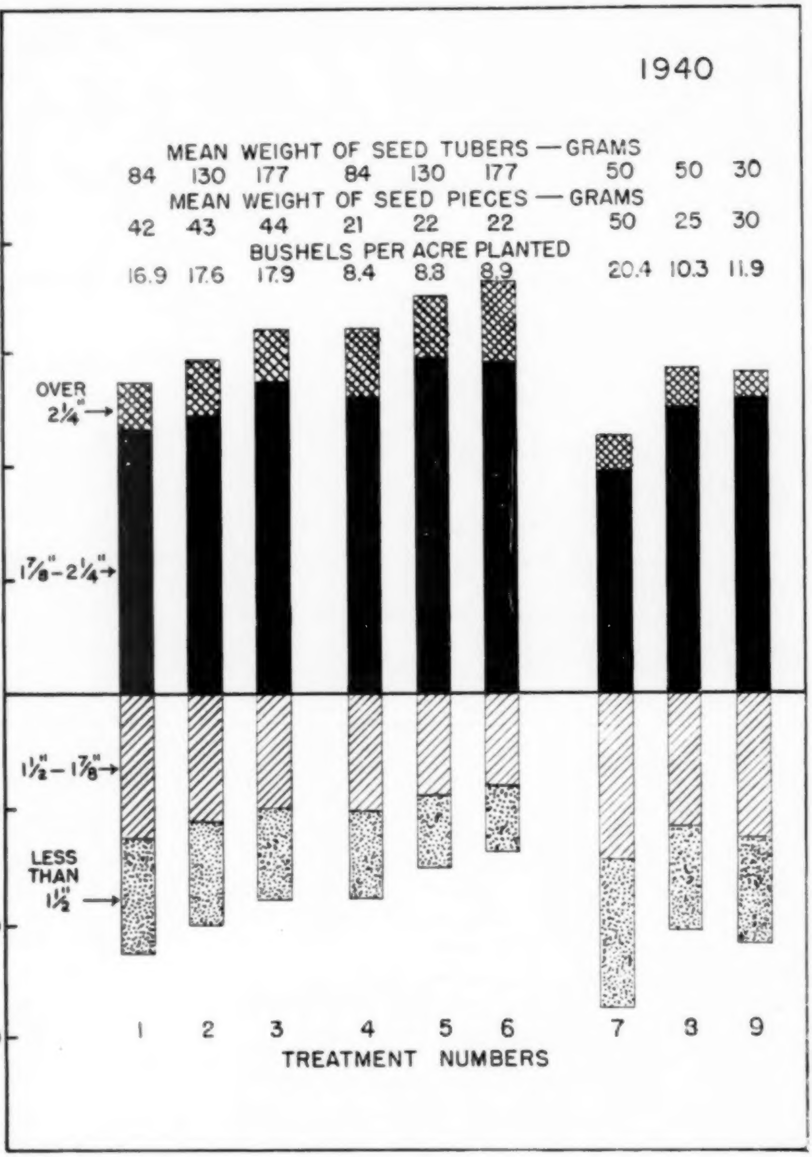

FIGURE 8.—The percentage of total weight of tubers of various sizes produced by small and large seed pieces derived from tubers of three sizes in 1940.

As usually is the case with seed piece size tests, more large tubers were produced by small seed pieces than by large pieces. The smaller seed potatoes produced more tubers of somewhat smaller size than did the large tubers. The increase in the number of tubers per given area (Figure 8) brought about by combination of better stands of plants and more stems per plant with the smaller seed tubers resulted in more competition, therefore a greater percentage of tubers were smaller than with the large seed tubers.

Literature Cited

1. Priestly, J. H. and J. M. Woffenden. 1923. The healing of wounds in potato tubers and their propagation by cut sets. Ann. App. Biol. 10: 96-115.
2. Shapovalov, M., and H. A. Edson. 1919. Wound cork formation in the potato in relation to seed piece decay. Phytopath. 9:483.
3. Werner, H. O. 1938. Wound healing in potatoes (Triumph Variety) as influenced by type of injury, nature of initial exposure, and storage conditions. Nebr. Agr. Exp. Sta., Res. Bull. 102.

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